

MODEL

ROCKETRY



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NOTE TO PARENTS

Rocketry is a relatively safe project when conducted under a few common sense rules. It is fascinating to watch and much more enjoyable if you participate yourself. Safety in design, construction and launching has been stressed throughout this book so that your child can avoid some of the most common mistakes of beginning rocketeers. Accidents do happen but are very rare considering the large number of model rocketeers. Why not make rocketry a family affair and join in the fun? You will be very glad you did.

ACKNOWLEDGEMENT

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4-H Areospace (Rocket) Project Expectations

Expected Experiences:

Beginners: 1 or 2 years

1. Study project book and know safety rules.
2. Construct one or more rockets - kits may be used.
3. Launch rocket at least two times.
4. Record your experience.
5. Exhibit
6. Give a demonstration to friends.

Some Experience: 2 or 3 years

1. Study additional rocket information from library or other sources.
2. Construct two or more rockets from intermediate or advanced levels.
3. Launch rockets two or more times using different size engines, new recovery system and under various weather conditions.
4. Record your activities.
5. Exhibit
6. Give a demonstration.

Advanced: 3 or more years

1. Read and study additional areospace rocket information.
2. Construct one or more rockets designed and built by you - not a kit.
3. Launch your rocket two or more times.
4. Record your activities.
5. Exhibit
6. Give a demonstration.

Advanced: 4 or more years

1. Use self-determined project.
2. Be a Jr. Leader for Rocket project.
3. Record your activities.
4. Exhibit
5. Give a demonstration.

AREOSPACE (ROCKET) 4-H PROJECT RECORD SHEET

Study expected experiences, do them, and record.

Name and type of Rocket	Date Completed	Number of Hours Spent	Cost	Date Launched	Engine Number	Type of Recovery System Used	Problems
Scissor-Wing Transport			\$6				

What were the weather conditions? (i.e. windy, calm, etc.)

What did I learn?

ROCKETRY

A MOST EXCITING PROJECT

Rocketry provides you the opportunity to learn the basic fundamentals of aerodynamics, develop skills in kit building and experience the thrills of launching your own rockets. Rocketry is relatively safe when the safety code is followed.

You can repeat this project several times by developing skill in building more difficult rockets and learning more about aerodynamic principles.

A rocket can be as small and simple in design as a badminton birdie mounted with an engine tube and launch lugs or, it can be a very complex design weighing as much as 16 ounces, being powered by several engines.

Beginners should start with rocket kits, simple in design and easy to build to develop skills in construction and aerodynamics. Rockets must be constructed with great care and precision to be assured of a stable flight. The prototypes have complicated electronic guidance systems to correct minor deviations. But, the model rocket relies entirely on the skill and judgement of it's builder and navigator.

Intermediates can build models requiring more skill, and expand into the multi-stage or cluster engine rockets. By this time you should have become interested enough to research the prototype. Before using multi-engine rockets, become thoroughly familiar with the proper installation and operational performance expected with each model.

Advanced rocketeers can build the most complex kit designs, as well as design their own rockets. They should be very familiar with the principles of aerodynamics. By this time you should be ready to enroll in the self determined Areospace project and expand your skills and knowledge as much as you care to get involved. You may even choose a career related to your interest in model rocketry.

Some of the models for advanced rocketeers will be flying over 300 miles per hour and may attain altitudes of several thousand feet.

ROCKETRY AS A GROUP PROJECT

Rocketry is fun as an individual project. However, it is much more fascinating when conducted with a group. You can organize recovery, tracking, launching and communications teams so each member will have an active assignment during the entire event.

You can have competition for the highest, fastest, most spectacular flight, best recovery, etc. There are any number of contests that can be held or you can launch on an individual flight plan. If your rocket is designed to haul payloads you can experiment with effects of flights on insects, conduct a contest to see who can recover a raw egg without breaking it, or any number of interesting things.

A FASCINATING HISTORY

We tend to think of the Space Age as starting in 1957 when the Soviet Union launched Sputnik I. Actually it all began back in the twelfth century. Marco Polo returned from China with reports about black powder being used as a propellant in the first crude rockets. By the year 1400 A.D. the French and English were developing several types of rockets. By the 16th century rockets were being replaced as weapons by the recently invented cannon and small firearms.

In the war of 1812, the British successfully used rockets against the United States at Chesapeake Bay. The battle inspired Francis Scott Key to write about the "rocket's red glare" in our National Anthem.

In 1846 Colonel A. Boyer was the first person to successfully fly a two stage rocket.

EARLY DEVELOPMENTS IN THE TWENTIETH CENTURY

Dr. Robert H. Goddard, "The Father of Modern Rocketry", began his work in 1909. He was the first to use liquid fuel and develop the mathematical theory of rocket propulsion and flight.

In 1923 Professor Herman Oberth wrote a book about the advantages and disadvantages of space travel and the use of space stations.

In 1929 the Germans developed JATO (jet assisted takeoff). This was a procedure used to help heavy planes take off from short runways.

In 1932 General Walter Dornberger began developing liquid fuel rockets to be used as weapons for war. In 1936 his guided missile research and development center began work on the V1 and V2 guided missile rockets which were directed on England in 1944.

At the close of World War II the German team of scientists was split between Russia and the United States. The best known scientist to come to the United States was Dr. Werner von Braun. Dr. Braun headed experiments at the Red Stone Arsenal where some of the early rockets such as the Private, Corporal, Aerobee, Viking, Firebird, and Gorgon II, were developed.

THE SPACE AGE TODAY

The Sputnik I launch in 1957 started the most rapid technological advances in any program, outside of a major war, in the history of man. Not only were rockets, engines, and fuels developed but entire new concepts of metallurgy, electronics, solar energy, medical technology, and communications. From these major developments came items that we now use in our everyday lifestyle. Except for the emphasis on rocketry most of these would never have come about because of the tremendous amount of money and personnel required for each project. Our homes have pocket calculators, digital clocks, and complex sound and communication systems as a result of the space program.

Eight centuries were required to get where we are today in the space program. We have walked on the moon and landed on Mars. We have seen centuries old dreams come true. As we keep on dreaming and developing our technology we will help future generations achieve the dreams that are yet to be realized. They will rely on much of today's technology, just as we have relied heavily on achievements of the past.

RESOURCE INFORMATION

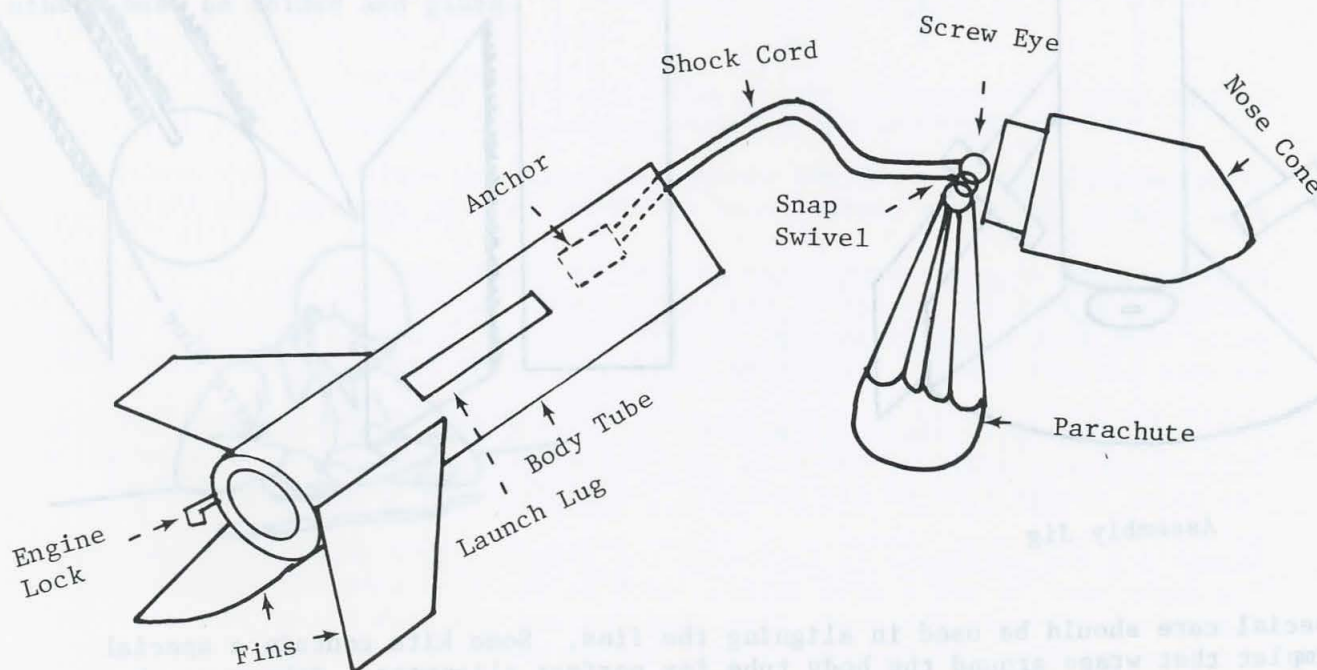
Rocketry is one of the most educational hobbies available. The principles involved in the aerodynamics and propelling of the large professional rockets are applied to the small models you will be building and launching.

There are two major sources of model rocket supplies. Both companies have printed large amounts of interesting and technical information which is available for a nominal fee. Club leaders are entitled to receive the Educator's materials used for teaching rocketry in schools. The companies also provide discounts to clubs ordering kits and materials in volume. Their catalogs provide information on all aspects of model rocketry. You should obtain copies of these catalogs as soon as possible. Catalogs may be available at your local hobby shop or you can write directly to the firms.

Estes Industries, Box 227, Penrose, Colorado 81240
Centuri Engineering Company, P.O. 1988, Phoenix, Arizona 85001

Most model kits will come equipped with complete construction details and many kits will recommend what engines be used. They may also provide technical data and facts about the prototype. Kits using more than one engine will usually provide the technical data necessary for staging or clustering the engines. FOLLOW THEIR INSTRUCTIONS VERY CAREFULLY FOR SAFE, SUCCESSFUL LAUNCHINGS!

Your library should contain books on this very fascinating subject.



PARTS OF A ROCKET

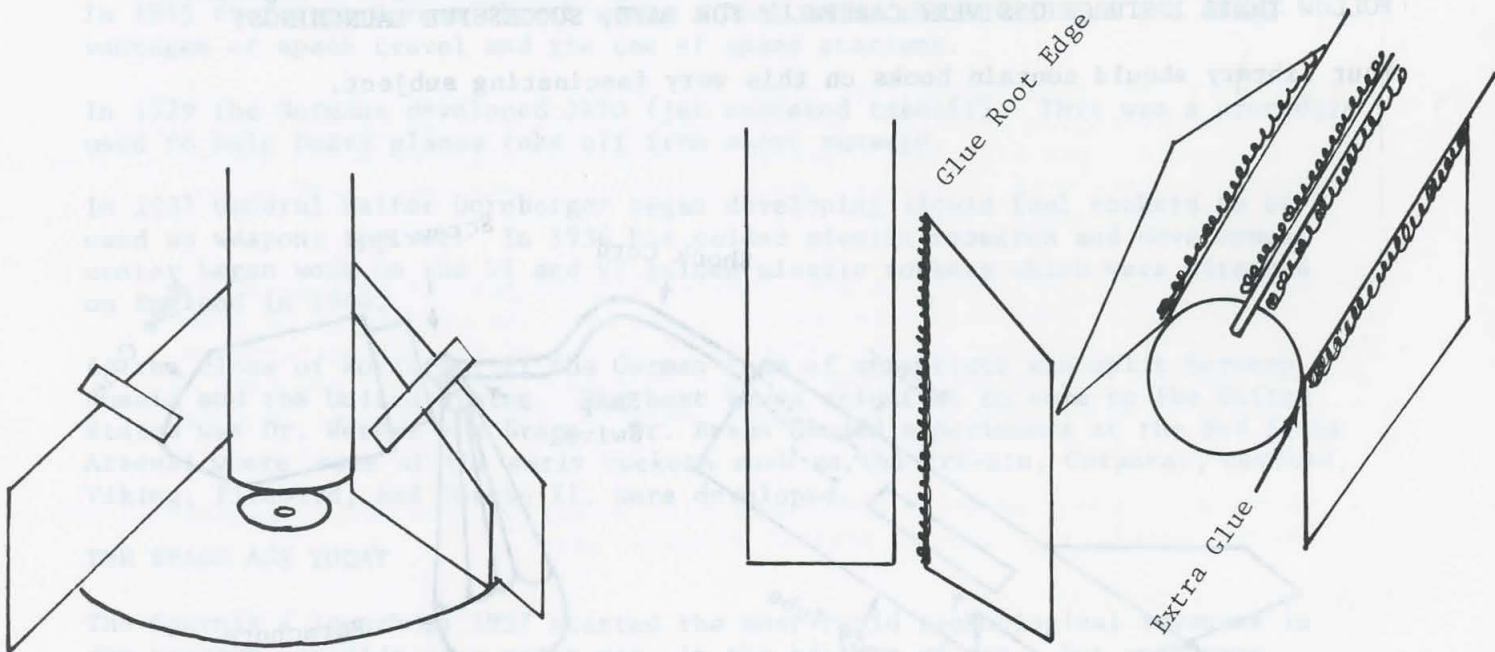
CONSTRUCTION

Few tools and materials are required to build model rockets. Some of the items needed are: glue, waxed paper, sander sealer, dope or enamel, modelor's knife, rubber bands or modelor's clamps, scissors and string.

Use care in measuring and cutting all parts. Paper tubes and balsa wood are extremely fragile and must be handled gently. Follow directions in the kit and do each step exactly as it says.

White glue is the most commonly used. Other types of faster setting glues are equally acceptable. It is impossible to use contact or fast setting glues in some areas where parts must be fitted inside the tubes. Be certain all parts are in their proper location while the glue is still wet. If you should damage or destroy a part, you can obtain individual parts at your hobby shop. Never use metal parts in constructing model rockets - the only approved use of metal in a model rocket is the small wire engine lock.

When you have advanced to designing your own rockets you can fashion your own parts by rolling paper into tubes and cutting parts from sheet balsa. You can purchase experimenter's kits which contain a large assortment of parts. Or, you may buy individual parts to meet your requirements.



Assembly Jig

Special care should be used in aligning the fins. Some kits contain a special templet that wraps around the body tube for perfect alignment. Others may have a circle divided to match the size of the body tube. Use a pencil to mark lines on the body tubes. If you plan to build several rockets you may wish to purchase a special jig which holds the fins against the body tub for perfect alignment. After the glue has set on the fins, run a bead of glue along each side of the fin and body. This will add great strength to the fins.

Be careful when aligning wings on certain models. If there are alternate wing position plans, be sure to use the design that will perform or glide in the manner that will best suit your requirements.

Engine stops must be placed at the proper distance to allow perfect fit of the engine. They must be glued very well. Engine blocks require special attention to see that they will accept the engine and hold it firmly in place. If an engine stop is not glued properly, the thrust of the engine will force the engine into the body of the rocket. An improper engine lock will allow the engine to pop out the back when the ejection charge is ignited, rather than separate the body and activate the recovery system.

Parts that are designed to be parted during the flight must be carefully fit to insure a smooth easy sliding separation. A nose cone fitted too tightly will not open. Double check these surfaces after you have painted your rocket to make certain they will slide apart easily.

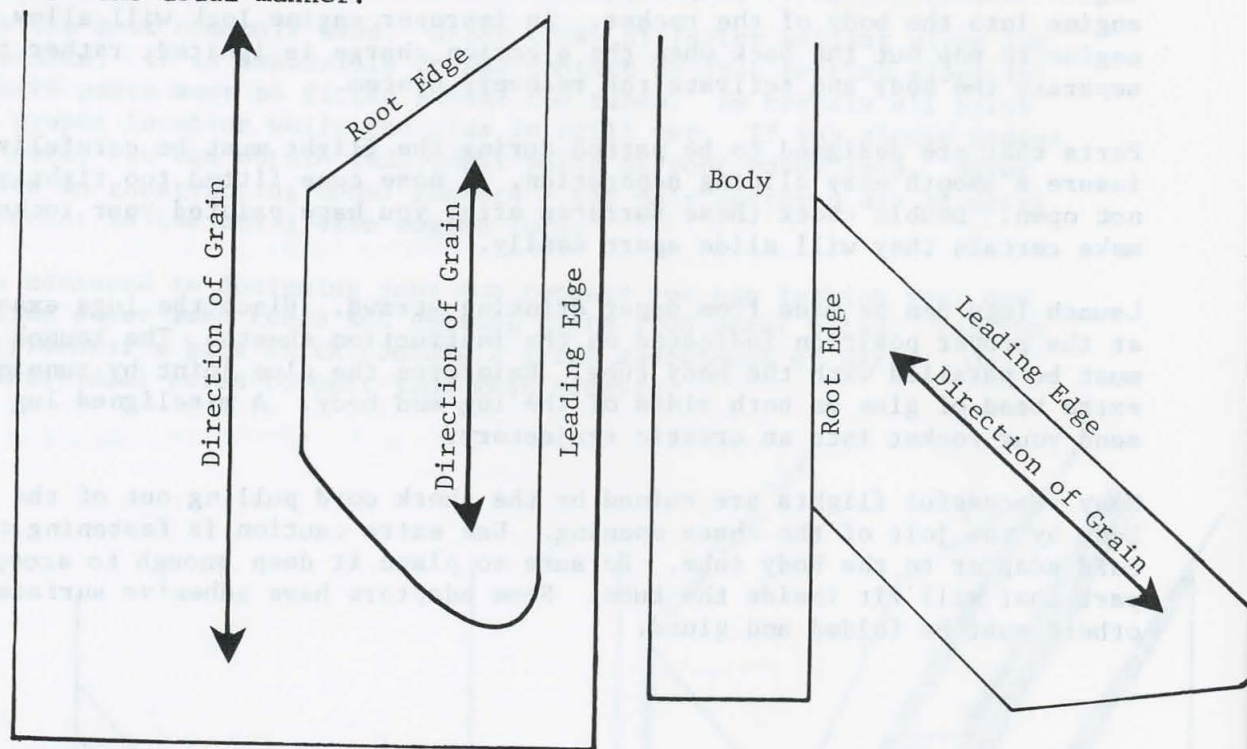
Launch lugs can be made from paper drinking straws. Place the lugs exactly at the proper position indicated on the instruction sheets. The launch lug must be parallel with the body tube. Reinforce the glue joint by running an extra bead of glue on both sides of the lug and body. A misaligned lug could send your rocket into an erratic trajectory.

Many successful flights are ruined by the shock cord pulling out of the rocket body by the jolt of the chute opening. Use extra caution in fastening the shock cord adaptor to the body tube. Be sure to place it deep enough to accept the part that will fit inside the tube. Some adaptors have adhesive surfaces while others must be folded and glued.



Many of the model kits will have precut fins. If you have to cut your own from sheet balsa, it is best to make a heavy cardboard pattern to draw on the balsa. Be sure the grain of the wood run parallel to the leading edge of the fin. To cut the fin, lay a ruler along the line and cut it with a sharp knife. A small modeler's back saw is very handy for cutting straight lines cross grain. When using a knife always be sure to lay the piece to be cut on heavy cardboard or wood to prevent damage to the table on which you are working.

Round the edges of the fin with sandpaper on all outside edges, leave the root edge (the edge which is fastened to the body) flat for a good gluing surface. Strength of the fins can be increased by gluing paper to both sides of the wood. Sand and file in the usual manner.



After assembling all parts and sanding them smooth, apply a sander sealer. Sand lightly and apply another coat of sander sealer, sanding very lightly.

Airplane dope or spray enamel can be used to paint your rocket. Avoid paint build ups around the inside of the engine tube, launch lugs, and on all sliding parts that must separate easily. A very fine sand paper or steel wool should be used between coats. Thin, even coats are better than a heavy, thick coat.

Too much paint will add extra weight. A rough finish will produce extra drag. Both of these conditions can slow your rocket considerably. Be sure to allow the paint enough time to dry properly before handling or applying decals.

Assembling the parachute is easy with the adhesive tabs supplied in the kit. You might want to add a snap swivel, such as the type used for fishing tackle. The swivel prevents the cords from tangling and the hook allows chutes to be attached quickly. If the rocket will not be used for some time, unfold the chute and store it in a flat open position.

MOUNTING THE ENGINE

There are two main types of engine mounts. One type employs a metal strip that springs back to allow the engine to enter. It has a hook on the end to hold the engine in place, while some engines are held in place by a friction fit. Sometimes it is necessary to wrap masking tape around the engine body to make it fit tighter.

Most engine mounts consist of an engine tube, spacers (called centering rings) to attach the engine tube to the body tube, and a paper ring, referred to as an engine block. The paper ring is glued in the forward end of the engine tube to prevent the engine from going forward into the body rather than propelling the rocket. Engines must be secured inside the tube to prevent the engine from being blown out the back during the ejection charge. If the engine is loose the gases will blow the engine instead of separating the rocket and allowing the recovery system to activate. Care in gluing the engine tube parts is very important. A faulty engine mount will usually result in a destroyed rocket.

RECOVERY SYSTEMS

There are several ways to slow the decent of your model rockets. Some models use more than one method:

A Parachute is attached to the rocket by means of an elastic or rubber band shock cord. Multiple chutes may be used on larger rockets.

Streamers are attached to lighter rockets and may be used in small fields with very little wind drift.

Featherweight rockets can eject the engine and float back to earth because of their light weight.

Tumble systems rely on the ejection charge to move the engine to an unbalanced position in the rocket. After losing stability, the rocket tumbles back to earth.

Helicopter systems have vanes on the rocket which cause it to spin slowly to the ground after it has lost thrust.

Glide systems employ wings which are fixed or may be designed to open up from the shock of the ejection charge.

PACKING THE CHUTE WADDING

Flame proof chute wadding should be used in recovery systems. Never use any type of wadding that has not been treated with a fire retardant chemical. The ejection gases are very hot and will catch untreated wadding on fire.

To determine the proper amount of wadding to use in a rocket, find the diameter of the body tube and multiply by $1\frac{1}{2}$ or 2. For example, if the body is one inch in diameter the length of the wadding would be $1\frac{1}{2}$ to 2 inches in length when packed into the body tube. Pack the wadding firmly, but not too tight. If the wadding is too loose a blow-by could result in a burned parachute or streamer, while wadding that is packed too tight could prevent separation of the body parts.

PACKING THE CHUTE

Care should be exercised in folding and rolling the chute. Try to prevent any tangles in the cords. Chutes must be able to unroll and open when the ejection charge has freed them from the body tube. Sprinkling the chute with chute powder, corn starch, or baby powder or talcum powder will prevent the plastic film from clinging together statically and will make the chute open faster. A generous portion of powder makes a highly visible "puff of smoke" when the chute is ejected, adding a dramatic effect to climax a perfect flight.

LAUNCH PADS

There are many commercial launch systems available at your local hobby shop. You can make your own system with just a few simple parts.

Thirty-six inch long metal rods are recommended. One-eighth inch diameter rod is used for the lighter models, while a three-sixteenths diameter rod is used for the larger and more powerful ones.

One system is easily constructed by cutting both ends from a large tin can. Cut the can along the seam and fold the can open in the center to form a tent. Fasten the four ends of the tin to a board, using screws or nails, and put a hole in the center of both pieces to accept the rod.

Another system requires only a wood base with a three inch circle of tin with a hole in the center. Any number of methods may be used if the base is large enough to prevent tipping and a blast deflector is used to prevent fires from the blast off.

A simple electrical system is used for launching. Almost any type of wire will be suitable. It must be long enough to allow the operator to remain at least ten feet away from the launch pad when firing. The switch can be a simple door bell switch or any type of a spring loaded (momentary contact) push button or toggle switch. Never use an ordinary on-off switch. This type could be left in the "on" position and fire the engine while you are attempting to fasten the clips to the igniter, causing a severe burn.

Small igniter clips can be obtained at your hobby shop. Or, you can use alligator clips which are available at an electronics store.

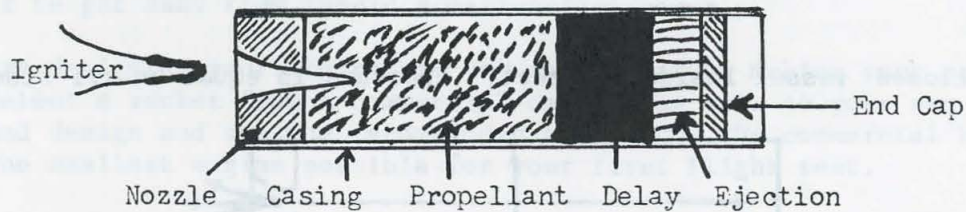
Any type of six or twelve volt battery will serve as your power source. You may use two large battery clamps and connect the system to a car battery of a nearby vehicle.

Provide a safety key to disable the system when connections are being made. A removable fuse or jumper wire with jacks will serve the same purpose. This enables the operator or launch commander to have complete control over the launch pad until all systems are go.

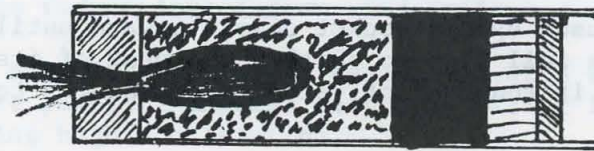
Multiple launch systems can be made by adding a rotary selector switch in series with the firing switch.

HOW A ROCKET ENGINE WORKS

Cutaway view of Engine



Battery operated launch system heats igniter and starts propellant burning.



Engine develops predetermined thrust. Action and reaction principle causes rocket to lift off.

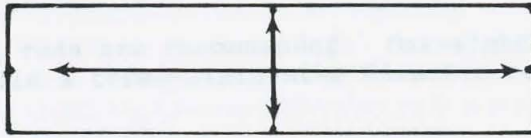


Delay charge burns slowly which allows the rocket to coast to peak altitude (Apogee) and produces smoke to aid in tracking.

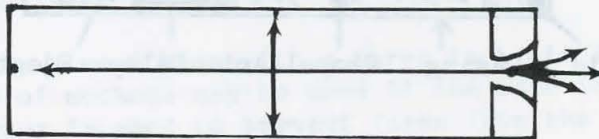


Ejection charge ignites, providing hot expanding gas which pushes forward inside the rocket and separates the rocket to activate the recovery system.

WHAT MAKES A MODEL ROCKET FLY?



Gasses in closed vessel inside a rocket. Pressure is equal on all sides.



Vessel open at one end. A pressure imbalance moves the rocket away from open end. A restriction at the nozzle end causes the gases to speed up as they leave the vessel.

All rocket engines operate on a reaction principal. High speed gases generated by a burning propellant escape from the nozzle, producing a reaction in the opposite direction. This, in turn, propels the rocket forward. Continued combustion causes a pressure imbalance which makes the rocket to fly faster and faster.

After the propellant is used up the rocket coasts upward until it runs out of velocity and starts to fall back to earth. The peak of its flight, which is the time between when it runs out of velocity and starts to coast, is called Apogee.

ENGINE CODING SYSTEM

First letter = total thrust code, which is the total power rated in Newton-Seconds. Each letter class is twice as powerful as the previous letter. Therefore, a C engine is twice as powerful as a B engine. A larger engine will provide more lift and will leave the launch pad at a higher rate of speed than an engine with a smaller letter.

First number = Average thrust in Newton-Seconds, which is the average push exerted by the engine. 1 pound = 4.448 Newtons.

Second number = Delay in seconds or coast time between end of burn and firing of the ejection charge. An engine with the number "0" indicates there is no delay charge and no ejection charge. This engine is used for booster stages only. (A three-stage booster rocket might require a B14-0 as a first stage, a B6-0 stage second stage and a B6-6 third stage.)

B 6 - 4

Engine

CHOOSING THE CORRECT ENGINE

All commercial kits will provide a list of recommended engines for each individual rocket. It is advisable to use the smallest rated engine for first flights. This will reduce the possibility of serious accidents caused by malfunctions or erratic flight patterns. A small engine will give a slower lift-off and enable you to observe the flight in more detail. Your rocket will do less damage on impact and is easier to get away from should a malfunction occur.

If you are designing your own rocket you should, after making your pre-flight tests, select a rocket from a commercial catalog as near to your own in size, weight and design and use the recommended engines or the commercial kit. Always employ the smallest engine possible for your first flight test.

Never use engines with delay times that are not recommended for your rocket's engines. An engine with too short a delay time will allow the ejection charge to fire before the rocket has slowed enough, resulting in tearing the chute apart or tearing out the complete recovery system. A delay charge that is too long will allow the rocket to plunge to the ground at a very high rate of speed. (For example, a large rocket weighing 4.5 ounces with a C6 engine would reach an altitude of 500 feet and would need only 3 seconds time to coast before the chute opened. A rocket weighing .6 ounces would attain an altitude of 1600 feet and would need 7 seconds to slow itself before firing an ejection charge.)

You may want to vary your flight in accordance with the size of the launching area, physical barriers such as buildings and trees, and wind conditions. IF IN DOUBT, USE THE SMALLER RECOMMENDED ENGINES. (Alterations of the recovery system can sometimes reduce losses from wind drift.)

For normal flying, engines with an average thrust of 3 to 7 Newtons are recommended. Employ more powerful engines only for lifting large payloads or for experiments involving high acceleration.

All commercial engines are standardized by the model rocket industry and are of uniform size and specifications. Engine mounts of one brand will readily accept engines of another company.

Do not buy more engines than you will use in any one season. Always store engines in a dry place. Commercial engines are a relatively safe and do not cause a problem in storing.

Caution: The chemicals used in the engines could be harmful if the engines are torn open. If you would like to see the inside of an actual engine, there are engines on the market that have been cut open and covered with plastic. They are available for a nominal price.

ENGINE IGNITERS

Several types of safe, reliable battery operated igniters are on the market. Some are designed for use with pen light batteries while others are designed for 6 or 12 volt batteries.

Igniters must be placed in the port as far as they will go, to be in contact with the fuel. (An igniter that is merely touching the ceramic end cap will result in a missfire because the end cap will not burn.) Some igniters are held in place by adhesive strips. Others are held in place by using a small piece of chute wadding. A small strip of tape will help hold the igniter in place.

NEVER, under any circumstances, use wicking or fuse type igniters that are lighted by a match. You should always be at least 10 feet away from the launch pad whenever the igniter is activated.

CLUSTER ENGINES

Large bulky rockets and heavy payloads rely on from 2 to 4 engines grouped together and fired simultaneously to provide enough thrust for first stage lift off and acceleration. Clustering is also used for new designs. Clustering allows building and testing in advance of the long period of time required to develop a new and more powerful engine. All engine igniters are wired in parallel. Take care to insure that all engines will receive the applied voltage at the exact same instant. A slight delay could result in failure of an engine to fire.

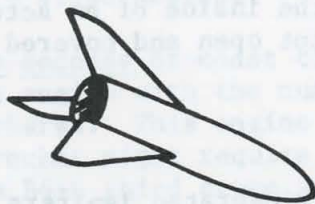
All commercial kits using cluster engines will provide complete instructions and technical information. Because of the weight of the engines at the rear and the amount of uneven thrust that may be applied at any given time, rockets have to be built extremely strong with an extra margin of stability. Cluster engine kits should only be attempted by experienced Rocketeers.

MULTI-STAGING ENGINES

The performance necessary for high orbits, moon shots and interplanetary probes is provided by multi-stage rockets. The principal advantage of this method is reducing weight of the rocket and payload as it gains altitude. As fuel is used, the spent engines are dropped off, thus allowing the remaining rocket and engines to continue their climb with more efficiency.

Engines must be butted together firmly. A complete seal around the joint is made by taping them with cellophane tape. The first stage engine is fired by an electrically activated igniter system. The second stage is fired by hot gases burning through the forward wall of the first stage engine just prior to burn out. As the gases enter the second stage engine through the ceramic nozzle or port, the fuel is ignited. The thrust created by the burning of the second stage engine will literally blow the spent first stage engine away from the second stage and cause it to tumble back to earth.

All commercial kits with multi-stage boosters will furnish complete instructions and technical information on this subject. Always study these reports to ensure a safe and successful flight. Multi-staging should only be attempted by experience Rocketeers.



THINK SAFETY.....AVOID ACCIDENTS

Rocketeers who think they can develop their own fuels and use pipes, sheet metal and wild concoctions are referred to as BASEMENT BOMBERS. They have earned their reputation by blowing up parts of their bodies and homes, often resulting in blindness and even death.

Most model rocket accidents are caused by people who do not follow the safety code. People who take chances and do things they know are contrary to common sense safety rules are usually the ones to get hurt. If you think a procedure might be wrong, don't do it.

Never use any type of fuel other than ARA approved commercially manufactured model rocket engines. Never use any type of igniters that are not battery activated, with at least enough wire to be able to stand ten feet away from the launch pad.

Discard wicks or fuses that are lighted by a match. Such wicks can burn in a flash which would not allow sufficient time to get away from the launch pad, or a wick could be smoldering and ignite when you approach it to replace or relight the fuse.

All rocketeers, regardless of their club affiliation, abide by the following safety code. This solid propellant model rocketry safety code is approved by the National Association of Rocketry and the Hobby Industry Association of America.

Model Rocketry Safety Code

1. CONSTRUCTION - My model rockets will be made of lightweight materials such as paper, wood, plastic and rubber, without any metal as structural parts.
2. ENGINES - I will use only pre-loaded factory made model rocket engines in the manner recommended by the manufacturer. I will not change in any way nor attempt to reload these engines.
3. RECOVERY - I will always use a recovery system in my model rockets that will return them safely to the ground so that they may be flown again.
4. WEIGHT LIMITS - My model rocket will weigh no more than 453 grams (16 ozs.) at liftoff, and the engines will contain no more than 113 grams (4 ozs.) of propellant.
5. STABILITY - I will check the stability of my model rockets before their first flight, except when launching models of already proven stability.
6. LAUNCHING SYSTEM - The system I use to launch my model rockets must be remotely controlled and electrically operated, and will contain a switch that will return to "off" when released. I will remain at least 10 feet away from any rocket that is being launched.
7. LAUNCH SAFETY - I will not let anyone approach a model rocket on a launcher until I have made sure that either the safety interlock key has been removed or the battery has been disconnected from my launcher.

8. FLYING CONDITIONS - I will not launch my model rocket in high winds, near buildings, power lines, tall trees, low flying aircraft, or under any conditions which might be dangerous to people or property.
9. LAUNCH AREA - My model rockets will always be launched from a cleared area, free of any easy to burn materials, and I will only use non-flammable recovery wadding in my rockets.
10. JET DEFLECTOR - My launcher will have a jet deflector device to prevent the engine exhaust from hitting the ground directly.
11. LAUNCH ROD - To prevent accidental eye injury I will always place the launcher so the end of the rod is above eye level or cap the end of the rod with my hand when approaching it. I will never place my head or body over the launching rod. When my launcher is not in use I will always store it so that the launch rod is not in an upright position.
12. POWER LINES - I will never attempt to recover my rocket from a power line or other dangerous places.
13. LAUNCH TARGETS & ANGLE - I will not launch rockets so their flight path will carry them against targets on the ground, and will never use an explosive warhead nor a payload that is intended to be flammable. My launching device will always be pointed within 30 degrees of vertical.
14. PRE-LAUNCH TEST - When conducting research activities with unproven designs or methods, I will, when possible, determine their reliability through pre-launch tests. I will conduct launchings of unproven designs in complete isolation from persons not participating in the actual launching.

As a 4-H member enrolled in the Model Rocketry Project, I promise to faithfully follow all rules of safe conduct as established in the above code.

Signed

Rodney Brown

PRE-LAUNCH TEST

Rocket stability should be tested before the rocket is actually launched. To accomplish this, make a loop in a piece of string six to ten feet long. Place an engine in the rocket and slide the string down the body of the rocket until the rocket is hanging in a perfectly level horizontal position. This is the rocket's center of gravity. Put a small piece of tape over the string to keep it in position.

While the rocket is suspended at its center of gravity, hold it overhead and swing it around in a circular path. If the rocket is stable it will point forward into the wind created by its own motion.

Some rockets will have to be pointed in a forward position before they will fly in a stable position. This can be done by holding the rocket in one hand and pivoting the

entire body as the rocket is started in a circular path. If you must hold the rocket to start it, an additional test should be made by moving the string back on the rocket body far enough to allow the nose to point down at a ten degree angle. Repeat the swing test, if the model will keep its nose pointed straight ahead once started it should be stable enough to fly.

Two methods may be used to make your rocket stable. 1. You may try adding weight to the nose cone. 2. You may enlarge the fins. You can also use a combination of these methods.

Some commercial kits supply supplementary plastic fins that must be used to stabilize flights. The fins of the proto type are not large enough to stabilize the model rocket. You may glue tabs to the existing fins by adding length or width or a combination of both in keeping with the design and appearance of the rocket. After making any changes go through the test procedure once more.

Never fly a rocket that has not passed the stability test. An unstable rocket may loop around harmlessly in the air. However, it may become stable after some of the fuel has burned up and come crashing to the ground at a very high rate of speed. If in doubt about the stability or construction strength of your rocket, never endanger the safety of yourself or others by launching it.

PREPARE TO LAUNCH

Rockets are extremely fragile. Exercise care when transporting them to the launch site. All rockets should be examined at the launch site for damage. Set aside any rocket needing repairs. Do not attempt to tape a broken fin or launch a rocket that has just been freshly glued.

Examine the launch area. Are there any electrical wires, buildings, or trees nearby? Is the area large enough to allow easy recovery? Avoid areas near a busy street or highway. Do not select a site that is in a flight pattern of a nearby airport.

Check the direction of the wind. You can make a small wind sock such as the type used at airports or fly a streamer. Winds are totally unpredictable and can change direction or gust at any time.

Set up the launching pad up-wind to allow for drift from wind currents on the recovery. Never attempt to launch if the wind is more than 20 miles per hour. Other wind currents may be present at different altitudes. Always use a small engine for a first flight test for such winds.

If rockets are drifting too far on their decent you can use a smaller chute, cut a center hole in the chute, or replace the chute with a streamer. Alterations to your recovery system will allow a faster fall and could damage your rocket on impact. These alterations are made for smaller launch areas and/or moderate winds and should never be done in an attempt to fly in high winds.

Check the area for highly combustible materials. Tall, dry grass can catch fire easily. Be prepared with water or beaters should a grass fire occur.

Set up the launching pad and pull the safety pin from the firing mechanism before connecting the battery. Make certain the blast deflector will keep the flame away from any combustibles on the ground. If possible the end of the launch rod should be high enough to prevent someone from bending over and bumping into the tip of the rod. Clear everyone at least 10 feet away from the launch area and begin the count down.

Never launch more than one rocket at a time. Never allow a rocket to be fired until the previously fired rocket has been fully recovered, thus enabling all eyes to focus attention on the airborne missile when it is launched.

Be certain all rockets have been given a Pre-Launch Stability Test. Retest any rocket that receives a payload or undergoes any type of change since it was last tested.

Flight data sheets are available. These allow space for recording all conditions of each flight including engines, recovery system, payloads, time, temperature, wind conditions, altitude and recovery information. A countdown checklist is also available to allow a procedural check of different types of recovery system.

GLOSSARY OF TERMS AND ABBREVIATIONS

AAM	Air to air missile identified by the name of a bird (Lark, Sparrow).
ABM	Anti Ballistic Missile used as a counter weapon to the ICBM.
ACCELERATION	The rate of increase in the speed of an object.
AERODYNAMICS	The branch of physics that deals with the forces exerted by air or other gases in motion.
AERONAUTICS	Science or art having to do with the design, manufacture, and operation of aircraft.
APOGEE	The point in the orbit of a rocket or satellite where it is farthest from the earth.
ASM	Air to surface missile identified by the name of birds of prey (Shrike).
AUM	Air to underwater missile.
AVERAGE THRUST	The total impulse of a rocket engine divided by the duration of total burn time. This is the thrust an engine would have if its thrust were constant from ignition to burnout.
BLOW THROUGH	An engine failure whereby the propellant blows out the forward end of the casing. Multi stage engines use this method to ignite the propellant in the following stage.
BOOSTER	A detachable portion of the rocket which contains an engine or engines to give the main rocket an initial velocity, which will separate from the main body after burnout and tumble to the ground.
BOOST GLIDER	A rocket designed to ascend vertically during the powered phase of its flight and becoming a gliding object after the ejection charge has fired.

BURN	The total amount of time the propellant is burning in the engine.
BURNOUT	The point at which a rocket engine burns up its fuel and ceases to produce thrust.
CENTER OF GRAVITY	The point on a rocket body where the weight is evenly balanced. This point will move by adding payloads and by the loss of weight of the engine as the propellant is burned.
CENTER OF PRESSURE	The center of all external air pressure on the complete rocket, including the body and fins.
CLUSTER	A group of two or more rocket engines set up to work as one
COMBUSTIBLE MATERIALS	Things that will catch fire and burn.
DECELERATION	The rate of decrease in the speed of an object.
DELAY CHARGE	A slow burning chemical added to the rocket engine to provide a time delay between burnout and activation of the recovery system.
DIRECT IGNITION	The safe, approved method of using an electrical system to ignite the engine propellant without the use of any fuse, squib, or wick.
DRAG	Aerodynamic forces acting to slow an object in flight.
DURATION	The length of time a model rocket engine produces thrust. The length of time a model rocket is airborne.
EJECTION CHARGE	A chemical added to the rocket engine to produce gas pressure at a very fast rate to activate the recovery system.
ENGINE BLOCK	Sometimes called a thrust ring. A hollow bulkhead which is usually a cardboard ring, fastened to the rocket body to transmit the engine thrust to the airframe while at the same time acting as a barrier to prevent the engine from moving forward during acceleration.
FIN	An aerodynamic surface projecting from the rocket body to give the rocket directional stability during flight.
ICBM	An Inter Continental Ballistics Missile having a range of six thousand miles or more.
IGNITER	An electrical device which initiates the combustion of the engine.
IGNITION	The instant a model rocket engine begins to burn and produce thrust.
MOMENTUM	The impetus of a moving object; equal to its velocity times its mass.
MONOPROPELLANT	A single mixture propellant which contains both the oxidizer and the fuel in a single compound.
MULTI-STAGE ROCKET	A rocket having two or more engines which are used at different stages of the flight.

NOSE CONE	An aerodynamically shaped shield which may be designed to carry a payload.
NOZZLE	The exhaust duct of a rocket engine in which the gases are accelerated to higher velocities due to the restriction of the opening.
PAYLOAD	Any objects to be lifted that are not a functional part of the rocket.
PAYLOAD CAPSULE	A compartment in the rocket designed to carry and protect a payload.
PEAK THRUST	Also referred to as maximum thrust. It is the greatest amount of thrust created by a rocket engine during its firing.
PERIGEE	The point in a satellite's orbit in which it is closest to earth.
PITCH	Rotational movement around the lateral axis of the rocket.
POUND SECONDS	The measure of total impulse given by a rocket engine. (average thrust times burning time, equals pound seconds).
PROTOTYPE	An original model on which other rockets are patterned.
RECOVERY SYSTEM	A device incorporated into the design of a model rocket for the purpose of returning it safely to the earth. All model rockets must use some form of recovery system.
ROLL	Rotational movement of a rocket about a longitudinal axis.
SAM	Surface to air missile identified by the names of mythological terms (Nike, Talos).
SHOCK CORD	An elastic cord used to attach the nose cone and parachutes to the body of the rocket, which absorbs the shock force of the ejection charge.
SOUNDING ROCKET	Term used for research rockets used to obtain data on the upper atmosphere.
STABILITY	The tendency of a rocket having a correct relationship between the center of gravity and the center of pressure to maintain a straight course.
SUM	Surface to underwater missile.
SUSTAINER ENGINE	The upper stage engine which remains with the rocket after the other stages have burned out and separated, producing thrust for the remainder of the journey.
THROAT	The smallest opening of the nozzle of a rocket engine.
THRUST	The propulsive force developed by the rearward ejection of gases during the combustion of the fuel.
TIME DELAY	The time between the burnout of the engine and the activation of the ejection charge.
TOTAL IMPULSE	The total amount of thrust developed by a rocket engine which is determined by multiplying the average thrust times the burning time.

UAM Underwater to air missile.

USM Underwater to surface missile.

WADDING A flameproof cotton or paper material that protects the parachute from the heat of the ejection charge and acts as a piston when pushing out the parachute.

YAW Rotation of a rocket about its vertical axis.

ABBREVIATIONS OF NATIONAL ORGANIZATIONS

ARA American Rocketry Association

NAR National Association of Rocketry

NAEC National Aerospace Education Council

NASA National Aeronautics & Space Administration